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TECHNICAL REPORT NO. LWL-CR-04-RAB

STUDY OF MARKING, SIGNALING AND ILLUMINATING DEVICES

Final Report
Contract No. DAAD05-68-C-0119

By
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Operations Research, Inc.
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March 1969

[redacted]

U. S. ARMY LIMITED WAR LABORATORY

Aberdeen Proving Ground, Maryland 21005

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ARMY LAND WARFARE LABORATORY
ABERDEEN PROVING GROUND, MD. 21005

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ABSTRACT

The parameters influencing the effectiveness of simple devices used to perform signal, illumination and marker functions during a combat mission have been identified.

An expression has been developed for the "utility" of a device for performing a signal, illumination or marker function in a given environment. A technique has been developed for deriving a family of devices to be used by a combat unit for performing such functions in support of a mission. A numerical index of effectiveness is used to rank alternative families of devices. The numerical index is expressed in terms of the "utility" values of the devices used to perform functions, the probabilities of requirements for functions and the essentiality of functions to the combat mission.

The technique for deriving families of devices was not exercised during this study effort. Suggestions for collecting data to use in the technique are included.

PREFACE

This study identifies the parameters to be considered in the selection of devices for performing signal, illumination and marker functions during a combat mission and incorporates them into a simple technique for deriving families of such devices to be carried by combat units.

No combat area surveys were made and no tests were conducted during this study.

This report was prepared for the Research Analysis Branch of the U.S. Army Limited War Laboratory by Operations Research, Inc. on completion of Work Assignment No. 7 under Contract DAAD05-68-C-0119.

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I. INTRODUCTION

BACKGROUND

Communications among combat units are accomplished, in general, with electrical or electronic devices. Visual communication devices such as pyrotechnics, lights, panels, flags, and balloons are used to provide unit-to-unit communications under two separate conditions relative to electronic means:

a. As a substitute for electronic communications when electronic means are not adequate or desirable.

b. To provide space and time orientation as a supplement to electronic communications.

Electronic devices provide fast, accurate communications and a capability to confirm readily each message. Transmission ranges generally exceed operational requirements. Visual communications are substituted when radio nets overload, when circuits are subject to electronic countermeasures, or when radio silence is required. Visual devices are used to provide space orientation in conjunction with electronic communications when identifiable geographic objects are absent or to provide time orientation in situations requiring coordination among units.

Army units in SE Asia are operating in a favorable situation with regard to communications capability. Radios are in widespread use. The enemy apparently has little countermeasure or direction finding capability.

Visual communication devices are used in the latter sense, i.e., to provide space and time orientation. They are employed most frequently for ground-to-air or air-to-air communications to provide effective control and coordination during airmobile operations.

The Joint Services inventory contains hundreds of devices to be used for signal, illumination and marker functions. The Limited War Laboratory (LWL) is currently engaged in programs to provide devices with special capabilities to permit effective operation under the environmental extremes experienced in SE Asia. A task has been established within LWL to study the interrelating functions of and requirements for signals, illuminators, and markers. The basic intent of the task is to identify a family of devices to meet the needs of the user and be relatively limited in number, weight, and bulk.

OBJECTIVE

As stated in the work assignment included as Appendix A, the objective of this study, which is a part of the LWL task, is as follows:

> "To develop a mathematical model for evaluating the effectiveness of signal, illumination, and marker devices and to exercise the model to identify a family of these devices which would provide the best capability in different missions and in various environments."

SUMMARY OF APPROACH

The problem is approached in 2 steps, as follows:

a. A technique for determining the "utility" of a device used to perform a signal, illumination or marker function in a given environment.

b. A technique for deriving a family of devices or basic load, to be carried by a combat unit for performing signal, illumination and marker functions during the accomplishment of its mission.

The task has been exploratory in nature. The techniques are not complete. Additional data are needed to test and exercise them. Data requirements are discussed in Section VII. However, the techniques are simple to use. Their value is dependent upon the quality of input data.

II. CONCLUSIONS

1. A technique for estimating the utility of a device for performing signal, illumination and marker functions in different environments has been developed and exercised. Results presented in tabular form are useful for identifying requirements for devices to meet special conditions.

2. A technique for deriving families of signal, illumination and marker devices to be carried by combat units has been outlined. The technique is valid and with additional data describing the probability of need for functions in different tactical situations and the essentiality of functions to different combat missions should prove to be a useful tool.

III. SIGNAL, ILLUMINATION AND MARKER FUNCTIONS

Missions which combat units are assigned include reconnaissance, fire support, resupply, search and destroy, base defense, convoy escort, and evacuation to include medical evacuations. The support functions that pyrotechnics, lights, panels, flags, balloons, and other types of visual communication devices might be expected to perform during a combat mission would include those listed in Table 1. They are classified as follows:

a. Signal—provides an alert or a time orientation

b. Illuminator—enhances operations during periods of relative low light conditions

c. Marker—provides a space orientation.

Several of the functions are both signals and markers.

The suggestions for additional effort in Section VII include a more comprehensive listing and definition of signal, illumination and marker functions.

TABLE 1

SIGNAL, ILLUMINATION, AND MARKER FUNCTIONS

	Signal (Alert or Time Orientation)	Illuminator	Marker (Space Orientation)
1. Signal distress	X		X
2. Initiate or coordinate action	X		
3. Reference mark to designate target			X
4. Reference mark to designate direction of movement			X
5. Signal unit location			X
6. Adjust friendly fire	X		X
7. Illuminate battlefield		X	
8. Illuminate LZ or DZ		X	
9. Delineate an area			X
10. Delineate moving force			X

IV. PARAMETERS INFLUENCING THE EFFECTIVENESS OF SIGNAL, ILLUMINATION AND MARKER DEVICES

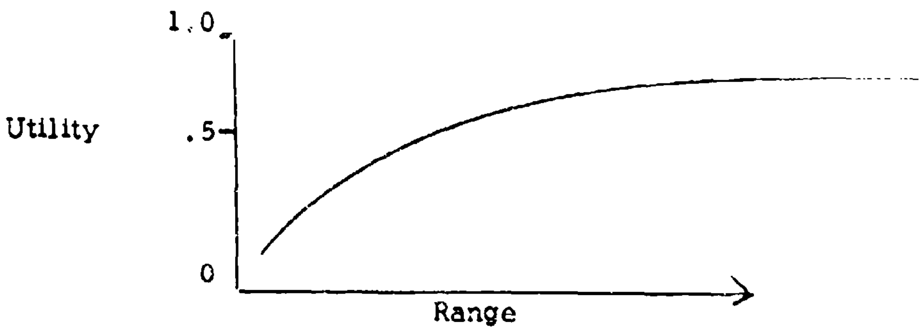
DEVICES TO PERFORM FUNCTIONS

The parameters to be considered in estimating the utility of a device used to perform a signal, illumination or marker function include the following:

Range

The range of visibility of a visual communication device is, in turn, a function of parameters such as the environment and the position of the observer relative to the device. Assuming there are no physical obstructions to vision, the range of visibility of the device is dependent upon its contrast relative to the background and the meteorological range of visibility. The contrast is a function of the color and brightness of the device relative to the background. The meteorological range is a function of time of day and weather conditions.

The utility of a device to perform a signal, illumination or marker function does not necessarily continue to increase with increasing range of visibility. For most functions, some value of range must exist beyond which the utility no longer increases. As an example, for a given function the utility of a device in terms of range might be represented by the curve in the figure below:



The utility of a device to perform a signal, illumination or marker function, in terms of range, may vary from function to function.

Persistency

The persistency of a device is, in general, a function of the device itself. However, the utility of a given device to perform a signal, illumination or marker function, in terms of persistency, may vary from function to function in a manner similar to that described with the discussion and curve in the previous paragraph. In addition, the indefinite persistency provided by a device such as a marker ribbon may be detrimental in some instances.

Multi-color or Multi-transmission Capability

In a situation where electronic communication devices are not in use, a multi-color capability is important for the purpose of providing a variety of different messages. The color for each particular message should be specified in the unit SSI. When electronic communication devices are in common use, a multi-color capability is important for another reason. When units are in radio contact, action is generally not taken on the basis of a visual signal only. A radio confirmation is made. However, a multi-color capability is important in this situation to lessen the possibility of the enemy's countermeasuring a signal or marker with a device of like color.

During simple actions involving only a couple units, several colors are generally quite adequate. However, during large scale airmobile operations there are situations in which a large number of different colors of a device would be desirable.

Reliability

The operational reliability of a device influences the utility of a device in a manner independent of the particular function to be performed.

Environment

For purposes of estimating the effectiveness of a device to perform a signal, illumination or marker function, the environment may be

described in terms of four factors: weather, light conditions, terrain and vegetation. Each of these factors may be described crudely in terms of two values as follows:

weather - favorable and unfavorable

light conditions - day and night

terrain - land and water

vegetation - canopy and no canopy.

The environment influences the devices and their utility in performing specific functions in different manners. Favorable weather conditions for one function may be unfavorable for another. Illuminators are not used, in general, during daylight conditions. The performance of pyrotechnics launched into the air is independent of the terrain.

FUNCTIONS PERFORMED BY A COMBAT UNIT DURING A MISSION

Having estimated the utility of a device to perform a given signal, illumination or marker function in a specific environment, the parameters to consider in assessing the effectiveness of the device to be used by a combat unit during the accomplishment of its mission include the following:

Launch Requirements

The launch requirements of the device must be considered in terms of whether the given unit does or does not have the capability to launch the device and, if not, whether the unit can carry additional equipment for launching the device.

Weight, Volume and Common Uses

The weights, volumes and common uses which influence the number of devices to be carried by a unit are important in determining the total effectiveness of a device particularly when a unit's capacity to carry devices during a combat mission is restricted.

Safety

The toxicity, corrosivity and irritability of chemicals used in devices must be considered for the safety of the unit. Initially, devices are determined to be safe with no special precautions necessary, safe if special precautions or equipment are used, or unsafe to carry and use.

Essentiality of Function

Certain signal, illumination and marker functions are more essential to the success of a combat mission than others. In one situation, the mission may be specifically to perform a given signal, illumination or marker function in which case the function would be highly essential to the success of the mission. Contrasted to this situation, a device is frequently carried by each soldier to signal distress if lost. In this case, the function is not particularly essential to the success of the mission but to the safety of the individual soldier.

Probability of Requirement for Function

The frequency of demand or probability of requirement for a given signal, illumination or marker function influences the effectiveness of a device to perform that function relative to the effectiveness of devices for other functions within the family. The probability must be considered in terms of a requirement for the function once, the requirement for the function a second time having been performed once, etc.

V. TECHNIQUE FOR ESTIMATING THE UTILITY OF A DEVICE FOR PERFORMING A SIGNAL, ILLUMINATION OR MARKER FUNCTION

Given a signal, illumination or marker function to be performed in a given environment, the "utility" of a device to be used is a relative measure of the value of the device for the given function and environment. It is the first step in determining effectiveness of the device which considers also the combat mission and the constraints imposed by the combat unit accomplishing the mission.

The "utility" of a device, D, for performing a signal, illumination or marker (SIM) function, F, in a given environment, E, is represented by the following expression:

$$U_{DEF} = R_D \cdot S_{DF} \cdot \delta_c \cdot \delta_r \cdot \delta_p \cdot \delta_l \cdot \delta_t \cdot \delta_v$$

where R_D = reliability of D, $0 \leq R_D \leq 1$.

S_{DF} = intended service of D.

$$S_{DF} = \begin{cases} 1, & \text{if D designed primarily to perform F.} \\ .5, & \text{if D not designed primarily to perform F but can be used with some degraded performance} \\ 0, & \text{if D has no application to F.} \end{cases}$$

δ_c = measure of D to meet multi-color or multi-transmission requirements for F

$$\delta_c = \begin{cases} C_D/C_F, & \text{if } C_D < C_F \\ 1, & \text{if } C_D \geq C_F \text{ or if criteria not applicable} \end{cases}$$

C_D = no. of colors or types of transmission available with D

C_F = no. of colors or types of transmission desired to perform F.

δ_r = measure of D to meet range requirements for F

$$\delta_r = \begin{cases} r_D/r_F, & \text{if } r_D < r_F \\ 1, & \text{if } r_D \geq r_F \text{ or if criteria not applicable} \end{cases}$$

r_D = range of visibility or transmission of D under favorable conditions of environment (in miles)

r_F = range of visibility or transmission desired to perform F (in miles).

δ_p = measure of D to meet persistency requirements

$$\delta_p = \begin{cases} P_D/P_F, & \text{if } P_D < P_F \\ 1, & \text{if } P_D \geq P_F \text{ or if criteria not applicable} \end{cases}$$

P_D = persistence of D (in seconds)

P_F = persistency desired to perform F (in seconds).

δ_l = measure of restrictions due to light conditions, light condition specified as day/night.

$$\delta_l = \begin{cases} 1, & \text{if device is intended for day (night) use and environment is day (night) or if device performance is independent of light conditions} \\ .5, & \text{if device is intended for day (night) use and environment is night (day) but device functions with reduced capability} \\ 0, & \text{otherwise} \end{cases}$$

δ_t = measure of restrictions due to terrain conditions, terrain condition specified as water/land.

$$\delta_t = \begin{cases} 1, & \text{if environment is land or if environment is water and device is designed to perform on water or if performance of D is independent of terrain} \\ .5, & \text{if environment is water and D performs on water but with reduced capability} \\ 0, & \text{if environment is water and D can not be used over water} \end{cases}$$

δ_v = measure of restrictions due to vegetation, vegetation specified as canopy/no canopy.

$$\delta_v = \begin{cases} 1, & \text{if environment is no canopy or if environment is canopy and device is designed to penetrate canopy or if performance of D is independent of vegetation} \\ .5, & \text{if environment is canopy and D performs under canopy but with reduced capability} \\ 0, & \text{if environment is canopy and D can not be used under canopy} \end{cases}$$

The technique is exercised for those devices included in references 1, 2, and 3 and for a few additional devices for which data were available from other sources. The results of this exercise are included in tables in Appendix B. The individual functions, as defined in Section III, were grouped as signal functions, illumination functions, and marker functions for purposes of this exercise. The entries in the tables across the rows describing function and environment and down from a given column describing a device are the utility values for the device. Each utility is expressed in terms of the 8 factors defining the utility and then, in turn, the product of the factors. This detail was included to illustrate the use of the technique.

Practically no data were available to describe reliability of a device. A reliability of one was used if no data were available.

For purposes of exercising the technique, where applicable, a multi-color requirement value of $C_r = 4$ was chosen. This is a value that should be better defined during future efforts.

Little data were available to describe the range, R_D, of devices. Several requirements for new devices specified range requirements, R_r, however, the values were inconsistent and no background information was available to substantiate the values. Values of candlepower were available for some illuminating devices and weight of charge for some smoke grenades. Burning times were available for most devices. An attempt to develop a simple, quick method for estimating range of visibility from this information was not successful. A valid, but time consuming technique is described in reference 4. Investigation did indicate that, in general, devices are overdesigned in terms of candlepower and burning times. Values of one were used for δ_r and δ_p in almost all cases.

It was assumed that the observer was aboard an airborne platform. This assumption describes the common situation in which such devices are used. It is particularly significant for the vegetation condition of canopy.

Complete tables displaying the information in the form shown in Appendix B would be useful for an agency responsible for the development of materiel of this type. They would identify areas in which deficiencies exist and would serve as a useful tool in responding to requirements for new devices.

The weight, volume and launch requirements for each device are also included in the table.

The information in the tables could be filed on punch cards and printed out in limited amounts, after sorts, in answer to a query.

VI. TECHNIQUE FOR DERIVING A FAMILY OF SIGNAL, ILLUMINATION AND MARKER DEVICES

A family of devices is characterized in terms of a mission to be accomplished by a combat unit. Typical missions for a combat unit were noted in Section III. Signal, illumination and marker functions that might be performed during a mission were listed in Table 1. The need for a combat unit to carry devices to perform these functions varies with the type of unit, mission and the environment in which the unit is operating. The quantity of each device to be carried by a unit depends on the common uses of the device, the frequency of demand to perform each function, and the duration of the mission. The constraints of number of individual items, bulk, weight and safety features influence the choice of actual devices to be carried by a unit on a particular mission in a given environment.

A unit that is relatively immobile or a unit that moves on wheels is not severely limited by these identifiable constraints in its stockage of devices to perform signal, illumination, and marker functions. In general, these devices are not too bulky nor heavy. However, the individual infantry soldier or the unit that moves on foot for great distances, such as the long range reconnaissance patrol, is extremely concerned about the size of the load to be packed. As might be expected, soldiers frequently tend to overload themselves with items that may influence their livelihood, e.g., with devices such as red smoke grenades for signalling distress.

In Section V, an expression was developed for "utility" of a device for performing a signal, illumination or marker function in a given environment. The expression for utility of a device does not consider the function relative to the combat mission nor the ability of devices to meet the constraints imposed by a combat unit. Knowing the utility of a device to perform a function in a given environment, a family of devices is characterized in terms of a mission to be accomplished by a combat unit.

The index of value of a device used to perform a function during the accomplishment of a mission, M, is given by the expression:

$$I_{MDEF} = \xi_{MF} \cdot P_{MF} \cdot U_{DEF}$$

where ξ_{MF} = the essentiality of F to M

P_{MF} = the probability that F will be required during M

U_{DEF} = the utility value defined in Section V.

The essentiality of a function to a mission, ξ_{MF}, provides a relative ranking for the importance of functions to the accomplishment of the mission and the survival of the combat unit. Table 2 provides a subjective set of essentiality ratings to be assigned to signal, illumination, and marker functions. The refinement of this set of values is included in the suggestions for additional effort in Section VII.

In terms of probability for requirements during a mission, the signal, illumination and marker functions may be classified as follows:

a. Function anticipated at most one time during a mission. An example would be signaling unit distress.

b. Function may be performed more than once during a mission. An example would be the marking of unit location.

c. Function to be performed exactly one time during a mission. An example would be the delineation of an area for preparation. The mission could be the actual performance of the given signal, illumination or marker function.

Suggestions for additional effort in Section VII include the collection of data for use in defining the probability of requirements for signal, illumination and marker functions during different combat missions.

TABLE 2

ESSENTIALITY RATINGS FOR SIGNAL, ILLUMINATION, AND MARKER FUNCTIONS

1.0	-	Highly essential. Mission cannot be accomplished without this function.
0.9	-	Highly essential. Survival of combat unit dependent upon this function
0.6	-	Moderately essential to accomplishment of mission.
0.5	-	Moderately essential to survival of combat unit.
0.1	-	Not very essential to accomplishment of mission or survival of combat unit.

Given a combat unit with a mission to be conducted in a specified environment, the steps necessary in the selection of a family of devices for performing signal, illumination, and marker functions are as follows:

1. Identify the signal, illumination, and marker functions anticipated during the mission.

These functions would be selected from the standard list in Table 1.

2. Assign an essentiality rating to each identified function.

Values are listed in Table 2. The essentiality rating ranks the identified functions in terms of their importance to the accomplishment of the mission and the survival of the combat unit.

3. Assign each function to a probability class and estimate the probability of a requirement for each function throughout the duration of the mission.

For functions in class a, a single probability must be estimated. For functions in class b, the probabilities must be estimated for a requirement once, twice, three times, etc., until the probability value nears zero. For functions in class c, the probability is one.

4. Identify absolute requirements for particular functions or devices and minimum numbers of each.

As an example, the SOP for a unit might require that each man in the unit carry a red smoke grenade to be used as a signal of distress.

5. List the functions in terms of decreasing order of values of the products $\xi_{MF} \cdot P_{MF}$ with the functions identified in step 4 at the top of the list.

This listing of the functions orders them in a manner such that those which are most important to satisfy with a given family of devices are at the top of the list.

6. Idenfity the constraints imposed by the combat unit in the selection of devices.

The constraints would include the limits on the numbers of individual items carried by each man and by the unit, the bulk in cubic feet, the weight in pounds, launch capability, and any safety restrictions.

7. Identify the devices available to the combat unit and capable of being launched by the unit

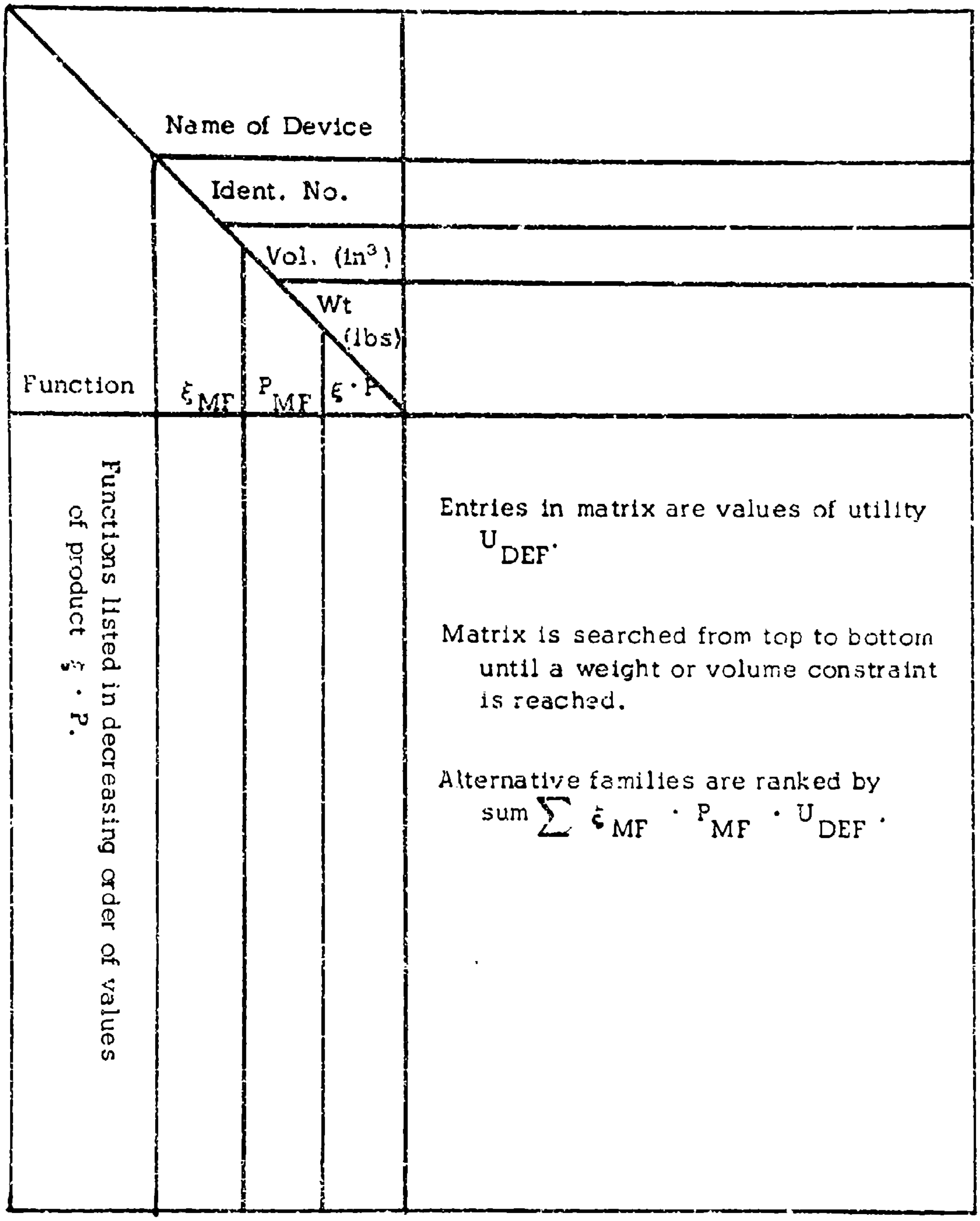


FIGURE 1. MATRIX FOR DERIVING FAMILY OF DEVICES

and that satisfy, with a non-zero utility value for the given environment, at least one of the specified functions.

The devices are to be selected from tables such as those included in Appendix B.

8. Identify devices carried by the unit for other purposes and that may be used for signal, illumination, and marker functions.

An example of this might be a mirror carried in the shaving kit and available for signaling from the ground to aircraft.

9. Construct a matrix of functions vs devices.

The functions are listed down the row headings in the order developed in step 5, i.e., functions for which there is an absolute requirement first and then followed by functions in terms of decreasing order of their assigned values of the products $\xi_{MF} \cdot P_{MF}$. The values of these products are listed with the functions. The devices selected in steps 7 and 8 are listed across the column headings in any order. The weight and volume of each device is included. The entries in the matrix are the utility values U_{DEF} for the given device in a given column to perform the listed functions in the specified environment. See Figure 1.

The effectiveness of a family of devices to perform a set of functions is the sum of the products

$$\sum \xi_{MF} \cdot P_{MF} \cdot U_{DEF}$$

for the devices selected in the family to satisy the functions considered. This sum is the expected value of the family where the product $\xi_{MF} \cdot U_{DEF}$ is the value of a term and P_{MF} is the probability of a requirement for its use.

Alternative families of device. can be selected from the matrix by choosing a device to satisfy each function down the list until a unit constraint of number of items, weight, or bulk is reached. In choosing a device to perform a given function, the utility value is most important provided that weight and volume of the device are not excessive. The family having the greatest effectiveness value and meeting the constraints imposed by the combat unit would be the most favorable for selection.

If a function is assigned a probability $P_{MF} = 1$, which would be the case for at least all those in class c, or if the function were among those for which there was an absolute requirement, the device selected

to perform it should be excluded from common use. If a function is assigned a probability $P_{MF} < 1$, a device selected to perform the function can be considered for common use. However, use of a single device to perform more than one function is not simple. A complete treatment of such cases would require the consideration of conditional probabilities, for example, the probability of function F_i being required and function F_j not being required during a given mission for all possible cases of a common use of a device to perform functions F_i and F_j.

In considering the devices identified during step 8 for selection for a family, weight and volume values of zero should be used since the devices are already a part of the unit load.

The more stringent of the weight and volume constraints imposed by the unit should dominate the selection of a family of devices from the matrix. As the matrix is searched from top down to satisfy the most important functions first, tallies should be kept on weight and volume of devices selected until a constraint is reached.

Because of lack of data, this technique for deriving families of devices has not been exercised. If the technique should be exercised during later efforts, additions and refinements are certain to be required. The method is simple, however, and is basically sound. The important parameters for selection of a family of devices are considered, with the exception of cost, which can be introduced and treated as a constraint in a manner similar to the weight and volume constraints or can be combined with effectiveness values of alternative families to derive cost-effectiveness scores for decision making.

VII. SUGGESTIONS FOR ADDITIONAL EFFORTS

The range, persistency and multi-color capability requirements for signal and marker functions are not well defined. The probability of detection of a signal or marker is a function of the range of visibility, the persistency and the cycle time of a device that operates intermittently. The range, in turn, is dependent on the contrast of the signal relative to the background and the meteorological range which is to say that the range is a function of the characteristics of the device and the environment. A comprehensive study to describe probability of detection in terms of these factors would assist planners in defining realistic range and persistency requirements for new developments. Currently, the tendency may be to overdesign devices for range and persistency. In terms of multi-color capability, there are situations in which as many colors as possible would be desirable for purposes of deception.

The tables in Appendix B are far from complete. A set of tables with more complete and up-to-date information would be valuable for purposes of identifying areas in which requirements exist for devices and for responding to requests for special purpose devices. The information from these tables could be put on punch cards in a format such that simple sorts and print-outs would provide information in a more usable form.

Data are needed for describing the probability of a requirement for each signal, illumination and marker function during a given combat mission and the essentiality o each function to the mission. Figure 2 is a form designed to collect data for describing these factors. Data

could be solicited from officers returning from the combat zone to central places such as schools. It should not be necessary to introduce these forms into the combat area to collect data.

Complete one form for each identifiable mission. Form designed for small units, company or smaller.

1. Unit__________. 2. Strength of Unit__________.

3. Mission (circle one or more or make entry in other): reconnaissance, fire support, resupply, search & destroy, base defense, convoy escort, evacuation, MEDEVAC, other__________.

4. Approximate date mission started__________. 5. Approximate duration of mission__________.

6. Other units participating in mission__________.

7. Environment (circle one in each pair or estimate % time each experienced): a. Day___/Night___. b. Water___/Land___. c. Canopy___/No Canopy___. d. Weather favorable___/Unfavorable___.

8. Signal, Illumination, Marker Devices used during mission:

Functions Performed	No. of Times Performed	Device(s) used Ident No.&Quantity	Essentiality to Mission (Check One)			Essentiality to Survival of Unit (Check One)		
			High	Moderate	Low	High	Moderate	Low
a. Signal distress								
b. Initiate or coordinate action								
c. Ref mark to designate target								
d. Ref mark to designate div of mov								
e. Signal unit location								
f. Adjust friendly fire								
g. Illuminate battle field								
h. Illuminate LZ or DZ								
i. Delineate on area								
j. Delineate moving force								
k.								
l.								
m.								
n.								

Figure 2. Data Collection Form for Signal, Illumination and Marker Devices.

LIST OF REFERENCES

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2. Department of the Army Technical Manual TM9-1330-200, "Grenades, Hand and Rifle," June 1966.

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3. D'Andrea, Joseph A., "Development of a 40 mm Position Marker," U.S. Army Limited War Laboratory Technical Report No. 68-01, January 1968. AD 827868.

APPENDIX A

WORK ASSIGNMENT

TITLE: Study of Marking, Signalling and Illuminating Devices (LWL Task 02-Y-68)

1. Work Assignment Number: 7

2. Contract Number: DAAD05-68-C-0119

3. Background:

The Joint Services inventory contains hundreds of different general and special-purpose devices to be used for signal, illumination, and marker functions. The Limited War Laboratory is currently engaged in numerous additional programs to provide similar items of equipment but with special capabilities which permit effective operation under the environmental extremes experienced in Vietnam. These new programs are responsive to stated and/or implied requirements originating in Vietnam which are aimed at providing either significantly increased performance or a capability where none existed previously. Unfortunately, it is seldom in the Army's best interest to provide a large number of specialized devices which meet only the peculiar needs of specific tactical situations.

In an attempt to identify those tasks which add appreciably to the military posture in LWL has established a task within the Labor to study the interrelating functions of and ments for markers, signals, and illuminators is further intended that this task will iden family of devices which would best meet all t needs of the user and still be relatively limit in number.

One of the steps in accomplishing such a study is the synthesis of a numerical indicator which provides some measure of the capability of a given concept or technique. Basic to the establishment of a numerical indicator of effectiveness is a mathematical model which relates the measurable characteristics of a technique to its predicted performance.

4. Objective:

To develop a mathematical model for evaluating the effectiveness of signal, illumination, and marker devices and to exercise the model to identify a family of these devices which would provide the best capability in different missions and in various environments.

5. Services to be Performed: The parameters affecting the performance and use of signal, illumination, and marker devices will be identified and defined in quantitative terms to the greatest extent practical. Such parameters include but are not limited to persistency, visibility, common uses, weight, volume, and cost. The interrelations of these parameters will be determined along with their influence on overall effectiveness of the devices when employed during given missions in various environments.

A model will be developed for evaluating the relative effectiveness of signal, illumination and marker devices employed during missions and in environments specified by LWL during the early study efforts. The model will express the index of effectiveness in terms of those parameters that affect the performance of the device in accomplishment of the stated mission.

The contractor will exercise the model to identify a family of signal, illumination, and marker devices that can be most effectively employed by a combat unit in the accomplishment of its assigned missions.

6. Testing Requirements: No tests are contemplated for this Work Assignment.

7. Items to be Delivered: The contractor shall submit the following written reports during performance of the Work Assignment (Reports shall be prepared and distributed pursuant to instructions set forth in paragraph 4, Exhibit "A", Scope of Work, of basic contract):

a. Monthly Letter Report

b. Final Work Assignment Report

This Work Assignment will be completed within three months, exclusive of Final Work Assignment Report, from the date of its acceptance by the contractor.

8. Government-Furnished Property and/or Assistance: No Government-furnished property and/or assistance is anticipated for this Work Assignment.

9. Estimated Cost: The total cost of this Work Assignment is estimated to be $10,000.00.

10. Hazardous Items: It is not anticipated that hazardous items will be involved in this Work Assignment.

APPENDIX B. TABLES OF UTILITY VALUES

The enclosed tables contain "utility" values as defined in Section V for devices used to perform signal, illumination and marker functions. All functions listed in Table 1 in Section III are categorized as signal, illumination or marker functions for purposes of this exercise.

To illustrate the technique, the entries in the table are expressed in terms of the 8 factors of the utility value, as defined in Section V, and in terms of the product of the factors. It was assumed that the observer was on an airborne platform. A required number of colors of 4 was chosen for calculating values for signal and marker functions. It was assumed that all devices met the requirements for range and persistency for the different functions.

Information on devices included in the table was extracted from references 1, 2, and 3 and a few additional sources.

TABLE B-1

SIGNAL, ILLUMINATION, AIRCRAFT

Name of Device	Signal, Illumination, Aircraft, Single Star		
Identification Number	AN-M43,A1,A1	AN-M44,A1,A1	AN-M45,A1,A2
Color(s)	R	Y	G
Air Launch		Yes	
Ground Launch		Yes	
Launch Requirements	AN-M8 or M9 for Ground Use		
Init. Time (sec)		5	
Ht. (ft)		250	
Pers (sec)		10 ± 3	
CP		25,000	
Range			
Vol (in^3)		7.5	
Wt(lbs)	0.27	1.26	1.37

Function	Light	Terrain	Veg	
Signal	Day	Land	Canopy	1·1·(.75)·1·1·(.5)·1·1 = .375
			No Can	= .375
		Water	No Can	= .375
	Night	Land	Canopy	1·1·(.75)·1·1·1·1·1 = .75
			No Can	= .75
		Water	No Can	= .75
Illumination	Night	Land	No Can	1(.5)·1·1·1·1·1·1 = .5
		Water	No Can	= .5
Marker	Day	Land	Canopy	1(.5)(.75)·1·1·(.5)·1·1 = .2
			No Can	= .2
		Water	No Can	= .2
	Night	Land	Canopy	1(.5)(.75)·1·1·1·1·1 = .375
			No Can	= .375
		Water	No Can	= .375
REMARKS				1. Reference TM9-1370-200.

TABLE B-1 (Cont)

Signal, Illumination, Aircraft, Double Star					
AN-M37, A1, A2 R-R	AN-M38, A1, A2 Y-Y	AN-M39, A1, A2 G-G	AN-M40, A1, A2 R-Y	AN-M41, A1, A2 R-G	AN-M42, A1, A2 G-Y
Yes					
Yes					
Pistol AN-M8 or Projector M9 for Ground Use					
5					
250					
10 ± 3					
25,000 each R star; 20,000 each G or Y star.					
7.5					
0.35	0.35	0.39	0.39	0.39	0.39
		1·1·1·1·1·(.5)·1·1	= .5		
			= .5		
			= .5		
		1·1·1·1·1·1·1·1	= 1		
			= 1		
			= 1		
		1(.5)·1·1·1·1·1·1	= .5		
			= .5		
		1(.5)·1·1·1·(.5)·1·1	= .25		
			= .25		
			= .25		
		1(.5)·1·1·1·1·1·1	= .5		
			= .5		
			= .5		

1. Reference TM9-1370-[illegible]00.
2. A1 series manufactured to less rigid and performance specifications than A2 series, A2 and A1 series have aluminum body; others have paper bodies.

TABLE B-1 (Cont)

Signal, Illumination, Aircraft, Tracer, Double Star					
AN-M53, A1, A2	AN-M54, A1, A2	AN-M55, A1, A2	AN-M56, A1, A2	AN-M57, A1, A2	AN-M58, A1, A2
Y Tracer	G Tracer	G Tracer	R Tracer	R Tracer	R Tracer
R-Y stars	R-R stars	G-R stars	G-G stars	R-R stars	G-R stars
Yes					
Yes					
Pistol AN-M8 or Projector M9 for Ground Use.					
5					
250					
Tracer 25-4 sec, star 3-4.5 sec.					
Tracers 30,000 Y or R, 25,000 G. Stars 48,000 R, 36,000 Y, 24,000 G.					
7.5					
0.40	0.38	0.38	0.38	0.39	0.39
1·1·1·1·1·(.5)·1·1 = .5					
= .5					
= .5					
1·1·1·1·1·1·1·1 = 1					
= 1					
= 1					
1(.5)·1·1·1·1·1·1 = .5					
= .5					
1(.5)·1·1·1·(.5)·1·1 = .25					
= .25					
= .25					
1(.5)·1·1·1·1·1·1 = .5					
= .5					
= .5					

1. Reference TM9-1370-200.

TABLE B-1 (Cont)

Signal, Smoke and Illumination, Aircraft AN-MK6, Mods 3 & 2
W
Yes
No
By hand
90
N/A
2400 to 3600
650
53.4
15.5
$1\cdot1\cdot(.25)\cdot1\cdot1\cdot1\cdot1\cdot0 = 0$
$1\cdot1\cdot(.25)\cdot1\cdot1\cdot1\cdot1\cdot1 = .25$
$1\cdot1\cdot(.25)\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$
$1\cdot1\cdot(.25)\cdot1\cdot1\cdot1\cdot1\cdot0 = 0$
$1\cdot1\cdot(.25)\cdot1\cdot1\cdot1\cdot1\cdot1 = .25$
$1\cdot1\cdot(.25)\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$
$1(.5)\cdot1\cdot1\cdot1\cdot1\cdot1\cdot1 = .5$
$1(.5)\cdot1\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$
$1(.5)\cdot(.25)\cdot1\cdot1\cdot1\cdot1\cdot0 = 0$
$1(.5)(.25)\cdot1\cdot1\cdot1\cdot1\cdot1 = .125$
$1(.5)(.25)\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$
$1(.5)(.25)\cdot1\cdot1\cdot1\cdot1\cdot0 = 0$
$1(.5)(.25)\cdot1\cdot1\cdot1\cdot1\cdot1 = .125$
$1(.5)(.25)\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$

1. Reference TM9-1370-200.
2. Four 3-unit candles burn in series, each producing 10-12" flame and white smoke.
3. Difference in 2 mods is in locations of fuze.

TABLE B-2

SIGNAL, ILLUMINATION, GROUND

Name of Device	Signal, Illumination, Ground, Star Cluster (5 stars)			
Identification Number	M18,A1,A2	M20,A1	M22,A1	M52,A1,A2
Color(s)	W	G	A	R
Air Launch	No			
Ground Launch	Yes			
Launch Requirements	M7 Rifle Grenade Launcher			
Init. Time (sec)	5.5			
Ht. (ft)	600			
Pers (sec)	4-10			
CP	18,000/star	7,000/star	2,000/star	35,000/star
Range				
Vol (in^3)	28.0			
Wt(lbs)	1.09			

Function	Light	Terrain	Veg		
Signal	Day	Land	Canopy	1·1·1·1·1·(.5)·1·1	= .5
			No Can		= .5
		Water	No Can		= .5
	Night	Land	Canopy	1·1·1·1·1·1·1·1	= 1
			No Can		= 1
		Water	No Can		= 1
Illumination	Night	Land	No Can	1(.5)·1·1·1·1·1·1	= .5
		Water	No Can		= .5
Marker	Day	Land	Canopy	1(.5)·1·1·1·(.5)·1·1	= .25
			No Can		= .25
		Water	No Can		= .25
	Night	Land	Canopy	1·(.5)·1·1·1·1·1·1	= .5
			No Can		= .5
		Water	No Can		= .5
REMARKS	1. Reference TM9-1370-200 and FM 23-30.				

TABLE B-2 (Cont)

Signal, Illumination, Ground Star Cluster (5 stars)			Signal, Illumination, Ground Star, Parachute (1 star)			
M125,A1 G	M158 R	M159 W	M17,A1 W	M19,A1,A2 G	M21,A1 A	M51,A1 R
No			No			
Yes			Yes			
Expendable rocket launcher.			M7 Rifle Grenade Launcher			
5			5.5			
600-700			600			
4-8			20-30			
9000/star			20,000	20,000	4,000	20,000
21.4			21.9			
1.3			1.04	1.02	1.0	1.02
1·1·(.75)·1·1·(.5)·1 = .375			1·1·1·1·1·(.5)·1·1 = .5			
= .375			= .5			
= .375			= .5			
1·1·(.75)·1·1·1·1·1 = .75			1·1·1·1·1·1·1·1 = 1			
= .75			= 1			
= .75			= 1			
1·(.5)·1·1·1·1·1·1 = .5			1(.5)·1·1·1·1·1·1·1 = .5			
= .5			= .5			
1(.5)(.75)·1·1·(.5)·1·1 = .19			1(.5)·1·1·1·(.5)·1 1 = .25			
= .19			= .25			
= .19			= .25			
1(.5)(.75)·1·1·1·1·1 = .375			1(.5)·1·1·1·1·1·1 = .5			
= .375			= .5			
= .375			= .5			

1. Reference TM9-1370-200 and FM 23-30.

1. Reference TM9-1370-200 and FM 23-30.

TABLE B-2 (Cont)

Signal, Illumination, Ground, Star, Parachute, (1 star) M126,A1	M127,A1 R	W No Yes	Signal, Illumination, Ground, Star, Parachute (1 star) M131 R No Yes
Expendable rocket launcher. 5 650-700 50 5,000	50,000	Expendable rocket launcher. 5 1500 30 10,000
 20.3 1.3	30-35 mi. 22.3 1.21
1·1·(.5)·1·1·(.5)·1·1 = .25 = .25 = .25 1·1·(.5)·1·1·1·1·1 = .5 = .5 = .5	1·1·(.25)·1·1·(.5)·1·1 = .125 = .125 = .125 1·1·(.25)·1·1·1·1·1 = .25 = .25 = .25
1·(.5)·1·1·1·1·1·1 = .5 = .5	1·(.5)·1·1·1·1·1·1 = .5 = .5
1·(.5)·(.5)·1·1·(.5)·1·1 = .125 = .125 = .125 1(.5)(.5)·1·1·1·1·1 = .25 = .25 = .25	1·(.5)·(.25)·1·1·(.5)·1·1 = .1 = .1 = .1 1·(.5)·(.25)·1·1·1·1·1 = .125 = .125 = .125
1. Reference TM9-1370-200, FM 23-30 and FM 20-60.	1. Reference TM9-1370-200.

TABLE B-2 (Cont)

Signal, Kit, Personnel, Distress A/P 25S-1 R No Yes	Elevated Site Marker LWL 10-M-67 Balloon cover color options No Yes
Projector in kit. 300-450 5 8,000	Balloon tether 14,400 sec
0.4/signal	5 mi. 4.5
1·1·(.25)·1·1·(.5)·1·1 = .125 = .125 = .125 1·1·(.25)·1·1·1·1·1 = .25 = .25 = .25	1·(.5)·1·1·1·1·1·1 = .5 = .5 = .5 1·(.5)·(.25)·1·1·1·1·1 = .125 = .125 = .125
1·(.5)·1·1·1·1·1·1 = .5 = .5	1·0·1·1·1·1·1·1 = 0 = 0
1(.5)(.25)·1·1·(.5)·1·1 = .1 = .1 = .1 1(.5)(.25)·1·1·1·1·1 = .125 = .125 = .125	1·1·1·1·1·1·1·1 = 1 = 1 = 1 1·1·(.25)·1·1·1·1·1 = .25 = .25 = .25
1. Reference TM9-1370-200. 2. Kit contains projector, 7 signals SDK-15/p 25S-1 and an instruction sheet.	1. Balloon with xenon flashing light.

TABLE B-2 (Cont)

Position Marker, Ribbon		Grenade, Hand, Illuminating	
		Mark 1	
		W	
No		No	
Yes		Yes	
M79 Grenade Launcher		Hand thrown.	
		7	
		N/A	
Indefinite		25	
		55,000	
		16.4	
		0.63	
1(.5)(.25)·1·1·1·1·1	= .125	1·1·(.25)·1·1·(.5)·1·0	= 0
	= .125	1·1·(.25)·1·1·(.5)·1·1	= .125
1(.5)(.25)·1·1·1·0·1	= 0	1·1·(.25)·1·1·(.5)·0·1	= 0
1(.5)(.25)·1·1·0·1·1	= 0	1·1·(.25)·1·1·1·1·0	= 0
1(.5)(.25)·1·1·0·1·1	= 0	1·1·(.25)·1·1·1·1·1	= .25
1(.5)(.25)·1·1·0·0·1	= 0	1·1·(.25)·1·1·1·0·1	= 1
1·0·1·1·1·0·1·1	= 0	1·1·1·1·1·1·1·1	= 1
1·0·1·1·1·0·0·1	= 0	1·1·1·1·1·1·0·1	= 1
1·1(.25)·1·1·1·1·1	= .25	1·(.5)·(.25)·1·1·(.5)·1·0	= 0
	= .25	1(.5)(.25)·1·1(.5)·1·1	= .1
1·1(.25)·1·1·1·0·1	= 0	1(.5)(.25)·1·1·(.5)·0·1	= 0
1·1(.25)·1·1·0·1·1	= 0	1(.5)(.25)·1·1·1·1·0	= 0
	= 0	1(.5)(.25) 1 1 1 1 1	= .125
1·1(.25)·1·1·0·0·1	= 1	1(.5)(.25)·1·1·1·0·1	= 0
1. Long term tree top delineator.		1. Reference TM9-1370-200 and FM 20-60 2. Can be activated remotely by wire.	

TABLE B-3

SIGNAL AND TARGET MARKER, SMOKE, GROUND

Name of Device	Signal, Smoke, Ground			
Identification Number	M62	M64	M65	M66
Color(s)	R	Y	G	V
Air Launch	No			
Ground Launch	Yes			
Launch Requirements	M7 Rifle Grenade Launcher.			
Init. Time (sec)	5.5			
Ht. (ft)	600			
Pers (sec)	20 sec in 5 mph wind			
CP	N/A			
Range	5 mi. on clear day			
Vol (in^3)	28.8			
Wt(lbs)	0.89			

Function	Light	Terrain	Veg		
Signal	Day	Land	Canopy	1· 1· 1· 1· 1· 1· 1· 1	= 1
			No Can		= 1
		Water	No Can		= 1
	Night	Land	Canopy	1· 1· 1· 1· 1· 0· 1· 1	= 0
			No Can		= 0
		Water	No Can		= 0
Illumination	Night	Land	No Can	1· 0· 1· 1 ·1 ·0 ·1 ·1	= 0
		Water	No Can		= 0
Marker	Day	Land	Canopy	1(.5)·1 ·1 ·1·1·1·1	= .5
			No Can		= .5
		Water	No Can		= .5
	Night	Land	Canopy	1(.5)·1 ·1 ·1·0·1·1	= 0
			No Can		= 0
		Water	No Can		= 0

REMARKS	
	1. Reference TM9-1370-200 and FM 23-30.
	2. Produces 6 smoke streamers down from height of trajectory.

TABLE B-3 (Cont)

Signal, Smoke, Ground Parachute M128A1/M128 G | M129A1/M129 R	Signal, Smoke, Ground XM166 W | XM167 G | XM168 R | XM169 Y
No	No
Yes	Yes
Hand-held rocket launch	By hand
5	3-5
450-500/650	N/A
40/15	Burns 13-30 sec.
N/A	N/A
	0.6 mi. from A/C at 1000 feet
21.4	1.9
1.25	
1·1·(.5)·1·1·1·1·1 = .5	1·1·1·1·1·1·1·0 = 0
= .5	1·1·1·1·1·1·1·1 = 1
= .5	= 1
1·1·(.5)·1·1·0·1·1 = 0	1·1·1·1·1·0·1·0 = 0
= 0	1·1·1·1·1·0·1·1 = 0
= 0	= 0
1·0·1·1·1·0·1·1 = 0	1·0·1·1·1·0·1·1 = 0
= 0	= 0
1·(.5)(.5)·1·1·1·1·1 = .25	1·1·1·1·1·1·1·0 = 0
= .25	1·1·1·1·1·1·1·1 = 1
= .25	= 1
1(.5)(.5)·1·1·0·1·1 = 0	1·1·1·1·1·0·1·0 = 0
= 0	1·1·1·1·1·0·1·1 = 0
= 0	= 0
1. Reference TM9-1370-200 for M128A1, M129A1; FM 23-30 for M128, M129.	1. Reference TM9-1370-200.

TABLE B-3 (Cont)

Signal, Smoke, Ground AN/M8 W No Yes	Signal, Smoke, Ground M18 R | G | Y | V No Yes
By hand 2 N/A 120 N/A	By hand 2 N/A 60 N/A
443 with adapter. 1.5	443 with adapter. 1.25
1·1·(.25)·1·1·1·1·0 = 0 1·1·(.25)·1·1·1·1·1 = .25 = .25 1·1·(.25)·1·1·0·1·0 = 0 1·1·(.25)·1·1·0·1·1 = 0 = 0	1·1·1·1·1·1·1·0 = 0 1·1·1·1·1·1·1·1 = 1 = 1 1·1·1·1·1·0·1·0 = 0 1·1·1·1·1·0·1·1 = 0 = 0
1·0·1·1·1·0·1·1 = 0 = 0	1·0·1·1·1·0·1·1 = 0 = 0
1·1·(.25)·1·1·1·1·0 = 0 1·1·(.25)·1·1·1·1·1 = .25 = .25 1·1·(.25)·1·1·0·1·0 = 0 1·1·(.25)·1·1·0·1·1 = 0 = 0	1·1·1·1·1·1·1·0 = 0 1·1·1·1·1·1·1·1 = 1 = 1 1·1·1·1·1·0·1·0 = 0 1·1·1·1·1·0·1·1 = 0 = 0
1. Reference TM9-1330-200 and FM 23-30.	1. Reference TM9-1330-200 and FM 23-30.

TABLE B-3 (Cont)

Signal, Smoke, Ground, Streamer	Signal, Smoke, Ground
M130 Y | T134 R | T135 G	M19/M19A1 WP | M20 HC | M22/M22A2 G | R | Y | V
No Yes	No Yes
Handheld Starts stream 50 ft. from firer N/A	Rifle Grenade Launcher Function on Impact N/A 60 N/A
314 1.25	27.2 1.26
1·1·(.75)1·1·1·1·0 = 0 1·1·(.75)1·1·1·1·1 = .75 = .75 1·1·(.75)1·1·0·1·0 = 0 1·1·(.75)1·1·0·1·1 = 0 = 0	1·1·1·1·1·1·1·0 = 0 1·1·1·1·1·1·1·1 = 1 1·1·1·1·1·1·0·1 = 0 1·1·1·1·1·0·1·0 = 0 1·1·1·1·1·0·1·1 = 0 1·1·1·1·1·0·0·1 = 0
1·0·1·1·1·0·1·1 = 0 = 0	1·0·1·1·1·0·1·1 = 0 1·0·1·1·1·0·0·1 = 0
1·1·(.75)1·1·1·1·0 = 0 1·1·(.75)1·1·1·1·1 = .75 = .75 1·1·(.75)·1·1·0·1·0 = 0 1·1(.75)1·1·0·1·1 = 0 = 0	1·(.5)·1·1·1·1·1·0 = 0 1(.5)·1·1·1·1·1·1 = .5 1(.5)·1·1·1·1·0·1 = 0 1(.5)·1·1·1·0·1·0 = 0 1(.5)·1·1·1·0·1·1 = 0 1(.5)·1·1·1·0·0·1 = 0
1. Reference FM 23-30.	1. Reference TM9-1330-200 and FM 23-30.

TABLE B-3 (Cont)

Signal, Smoke, Ground, Streamers M23/M23A1 G | R | Y | W No Yes	Grenade, Hand, Smoke M15 WP No Yes
Rifle Grenade Launcher N/A	By hand. 4-5 N/A 60 N/A
25.2 1.5/1.16	20.1 1.9
1·1·1·1·1·1·1·1·0 = 0 1·1·1·1·1·1·1·1·1 = 1 1·1·1·1·1·1·0·1 = 0 1·1·1·1·1·0·1·1 = 0 = 0 1·1·1·1·1·0·0·1 = 0	1·1·(.25)·1·1·1·1·0 = 0 1·1(.25)·1·1·1·1·1 = .25 = .25 1·1(.25)·1·1·0·1·0 = 0 1·1(.25)·1·1·0·1·1 = 0 = 0
1·0·1·1·1·0·1·1 = 0 1·0·1·1·1·0·0·1 = 0	1·0·1·1·1·0·1·1 = 0 = 0
1·(.5)·1·1·1·1·1·0 = 0 1·(.5)·1·1·1·1·1·1 = .5 1(.5)·1·1·1·1·0·1 = 0 1(.5)·1·1·1·0·1·1 = 0 = 0 1(.5)·1·1·1·0·0·1 = 0	1·1·(.25)·1·1·1·1·0 = 0 1·1·(.25)·1·1·1·1·1 = .25 = .25 1·1·(.25)·1·1·0·1·0 = 0 1·1·(.25)·1·1·0·1·1 = 0 = 0
1. Reference TM9-1330-200 and FM 23-30.	1. Reference TM9-1330-200 2. Bursting type grenade.

TABLE B-3 (Cont)

Grenade, Hand and Rifle, Smoke M34 WP No Yes	Signal, Smoke, Ground 40mm XM635 Y No Yes
By hand or projector M1A2 4-5 N/A 60 N/A	M79 and XM148 Grenade Launchers 1 250 120 N/A
24.6 1.5	
1·1·(.25)·1·1·1·1·0 = 0 1·1·(.25)·1·1·1·1·1 = .25 = .25 1·1·(.25)·1·1·0·1·0 = 0 1·1·(.25)·1·1·0·1·1 = 0 = 0	1·1·(.25)·1·1·1·1·1 = .25 = .25 1·1·(.25)·1·1·1·0·1 = 0 1·1·(.25)·1·1·0·1·1 = 0 = 0 1·1·(.25)·1·1·0·0 = 0
1·0·1·1·1·0·1·1 = 0 = 0	1·0·1·1·1·0·1·1 = 0 1·0·1·1·1·0·0·1 = 0
1·1·(.25)·1·1·1·1·0 = 0 1·1·(.25)·1·1·1·1·1 = .25 = .25 1·1·(.25)·1·1·0·1·0 = 0 1·1·(.25)·1·1·0·1·1 = 0 = 0	1·(.5)(.25)·1·1·1·1·1 = .125 = .125 1(.5)(.25)·1·1·1·0·1 = 0 1(.5)(.25)·1·1·0·1·1 = 0 = 0 1(.5)(.25)·1·1·0·0·1 = 0
1. Reference TM9-1330-200.	1. Reference ACTIV Report. AD 388 049. 2. Has foliage hang-up capability.

TABLE B-3 (Cont)

PM-1	PM-2	PM-3				PM-4
		Position Marker, Smoke, Ground, [illegible] mm				
		R	Y	G	W	
No Yes	No Yes	No Yes				No Yes
	M79 grenade launcher	M79 & M148 grenade launchers				
		1.75				
300 max		200-300				
120	[illegible]80	90				120
N/A		N/A				
		10.5				
		.47	.45	.46	.52	2.0
		1·1·1·1·1·1·1·1 = 1 = 1 = 1 1·1·(.25)1·1·1·1·1 = .25 = .25 = .25				
		1·.5·1·1·1·1·1·1 = .5 = .5				
		1·1·1·1·1·1·1·1 = 1 = 1 = 1 1·1·(.25)1·1·1·1·1 = .25 = .25 = .25				
1. Reference ACTIV Rept. AD388049. 2. Modified M127A1 Illumination signal.	1. Reference LWL Tech Rept. 68-01. 2. Has foliage hang-up capability.	1. Reference LWL Tech Rept. 68-01. 2. Has foliage hang-up capability. 3. White has night flare capability.				2. Has foliage hang-up capability.

TABLE B-4

SIGNAL AND TARGET MARKER, MARINE

Name of Device				Signal, Illumination, Marine, 2 star
Identification Number				AN-M75
Color(s)				R
Air Launch				No
Ground Launch				Yes
Launch Requirements				By hand.
Init. Time (sec)				2-4 sec 1st star, 4-8 sec 2nd star.
Ht. (ft)				175
Pers (sec)				4-6 sec per star
CP				8000 per star
Range				2½-3 mi. day, 12-15 mi. night
Vol (in^3)				6.1
Wt(lbs)				0.34
Function	Light	Terrain	Veg	
Signal	Day	Land	Canopy	1· 1(.25)· 1· 1(.5)·1·1 = .125
			No Can	= .125
		Water	No Can	= .125
	Night	Land	Canopy	1· 1(.25)·1· 1·1·1·1 = .25
			No Can	= .25
		Water	No Can	= .25
Illumination	Night	Land	No Can	1(.5)· 1·1·1·1·1 = .5
		Water	No Can	= .5
Marker	Day	Land	Canopy	1(.5)(.25)·1·1·(.5)·1·1 = .1
			No Can	= .1
		Water	No Can	= .1
	Night	Land	Canopy	1(.5)(.25)·1·1·1·1·1 = .125
			No Can	= .125
		Water	No Can	= .125
REMARKS				1. Reference TM9-1370-200.

TABLE B-4 (Cont)

Signal, Illumination, Marine Star MK2 Mod 0 G No Yes	Signal, Smoke, Marine AN-MK 1, Mod 1 O No Yes
Vary signal pistol MK5 6 600	By hand. 0 N/A Burns 18 sec. N/A
1.5 0.7	8.0 0.38
1·1(.25)·1·1(.5)·1·1 = .125 = .125 = .125	1·1(.25)·1·1·1·1·0 = 0 1·1(.25)·1·1·1·1·1 = .25 = .25
1·1(.25)·1·1·1·1·1 = .25 = .25 = .25	1·1(.25)·1·1·0·1·0 = 0 1·1(.25)·1·1·0·1·1 = 0 = 0
1(.5)·1·1·1·1·1·1 = .5 = .5	1·0·1·1·1·0·1·1 = 0 = 0
1(.5)(.25)·1·1(.5)·1·1 = .1 = .1 = .1	1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 = .125
1(.5)(.25)·1·1·1·1·1 = .125 = .125 = .125	1(.5)(.25)·1·1·0·1·1 = 0 1(.5)(.25)·1·1·0·1·1 = 0 = 0
1. Reference TM9-1370-200.	1. Reference TM9-1370-200. 2. Available in hand-held and floating types.

TABLE B-4 (Cont)

Signal, Smoke & Illumination, Marine		Target Marker, Marine, Smoke	
AN-MK13 Mod 0		EX-66 | EX-67 | EX-68	
O		R | Y | W	
No		Yes	
Yes		Yes	
By hand.		Firing pin device in base.	
0		3	
N/A		N/A	
Smoke 18 sec., Flare 18-20 sec.		180	
3,000 Flare		N/A	
10.6		134	
0.40		3.6	
1·1(.25)·1·1·1·1·0	= 0	1(.5)(.75)·1·1·1·1·0	= 0
1·1(.25)·1·1·1·1·1	= .25	1(.5)(.75)·1·1·1·1·1	= .375
	= .25		= .375
1·1(.25)·1·1·1·1·0	= 0	1(.5)(.75)·1·1·0·1·0	= 0
1·1·(.25)·1·1·1·1·1	= .25	1(.5)(.75)·1·1·0·1·1	= 0
	= .25		= 0
1(.5)·1·1·1·1·1·1	= .5	1·0·1·1·1·0·1·1	= 0
	= .5		= 0
1·(.5)(.25)·1·1·1·1·0	= 0	1·1(.75)·1·1·1·1·0	= 0
1(.5)(.25)·1·1·1·1·1	= .125	1·1(.75)·1·1·1·1·1	= .75
	= .125		= .75
1(.5)(.25)·1·1·1·1·0	= 0	1·1(.75)·1·1·0·1·0	= 0
1(.5)(.25)·1·1·1·1·1	= .125	1·1(.75)·1·1·0·1·1	= 0
	= .125		= 0
1. Reference TM9-1370-200. 2. Contains orange smoke cannister and pyrotechnic flare.		1. Reference ARPA Report. JRATA Project 26-505.1. 2. Dropped during tests from altitudes of 30-250 ft. from UH-1B, 2500 ft. from 01-F.	

TABLE B-4 (Cont)

Floating Landing Light		Target Marker, Floating, Smoke, 40mm	
LWL 07-E-68		TM F-1, LWL 01-F-68	
Colored filters available			
No		No	
Yes		Yes	
Hand placed.		M79 Grenade Launcher.	
0			
N/A		N/A	
5400		90	
2		1[1.]	
		3.0	
1(.5)·1·1·1·(.5)·1·0	= 0	1(.5)·1·1·1·1·1·0	= 0
1(.5)·1·1·1(.5)·1·1	= .25	1(.5)·1·1·1·1·1·1	= .5
	= .25		= .5
1(.5)·1·1·1·1·1·0	= 0	1(.5)·1·1·1·0·1·0	= 0
1(.5)·1·1·1·1·1·1	= .5	1(.5)·1·1·1·0·1·1	= 0
	= .5		= 0
1·1·1·1·1·1·1·1	= 1	1·0·1·1·1·0·1·1	= 0
	= 1		= 0
1(.5)·1·1·1(.5)·1·0	= 0	1·1·1·1·1·1·1·0	= 0
1(.5)·1·1·1(.5)·1·1	= .25	1·1·1·1·1·1·1·1	= 1
	= .25		= 1
1(.5)·1·1·1·1·1·0	= 0	1·1·1·1·1·0·1·0	= 0
1(.5)·1·1·1·1·1·1	= .5	1·1·1·1·1·0·1·1	= 0
	= .5		= 0
1. Incandescent battery powered.		1. Range applies also to color identification.	

TABLE B-5

FLARE, AIRCRAFT

Name of Device	Flare, Aircraft: Guide		
Identification Number	T6E1	T7E1	T8E1
Color(s)	W	R	G
Air Launch	Yes		
Ground Launch	No		
Launch Requirements	Air dropped		
Init. Time (sec)	6-7		
Ht. (ft)	N/A		
Pers (sec)	45-60		
CP	650,000	700,000	90,000
Range			
Vol (in^3)	125.8		
Wt (lbs)			

Function	Light	Terrain	Veg		
Signal	Day	Land	Canopy	1(.5)(.75)·1·1·(.5)·1·0	= 0
			No Can	1(.5)(.75)·1·1·(.5)·1·1	= .2
		Water	No Can	1(.5)(.75)·1·1·(.5)·0·1	= 0
	Night	Land	Canopy	1(.5)(.75)·1·1·1·1·0	= 0
			No Can	1(.5)(.75)·1·1·1·1·1	= .375
		Water	No Can	1(.5)(.75)·1·1·1·0·1	= 0
Illumination	Night	Land	No Can	1·1·1·1·1·1·1·1	= 1
		Water	No Can	1·1·1·1·1·1·0·1	= 0
Marker	Day	Land	Canopy	1(.5)(.75)·1·1·(.5)·1·0	= 0
			No Can	1(.5)(.75)·1·1·(.5)·1·1	= .2
		Water	No Can	1(.5)(.75)·1·1·(.5)·0·1	= 0
	Night	Land	Canopy	1(.5)(.75)·1·1·1·1·0	= 0
			No Can	1(.5)(.75)·1·1·1·1·1	= .375
		Water	No Can	1(.5)(.75)·1·1·1·0·1	= 0
REMARKS	1. Reference TM9-1370-200. 2. Designed for use with vertical drop bombs.				

TABLE B-5 (Cont)

Flare, Aircraft, Parachute M8A1 Soft Yellow Yes Yes	Flare, Aircraft, Parachute M9A1 Yes No
Air dropped. Flare stand A1 on Ground 3-5 N/A 165-195 350,000	Pistol AN-M8 2.5 N/A 60-70 60,000
358 17.6	47.3 2.11
1(.5)(.25)·1·1·(.5)·1·0 = 0 1(.5)(.25)·1·1·(.5)·1·1 = .1 1(.5)(.25)·1·1·(.5)·0·1 = 0 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 1(.5)(.25)·1·1·1·0·1 = 0	1(.5)(.25)·1·1(.5)·1·0 = 0 1(.5)(.25)·1·1(.5)·1·1 = .1 1(.5)(.25)·1·1(.5)·0·1 = 0 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 1(.5)(.25)·1·1·1·0·1 = 0
1·1·1·1·1·1·1·1 = 1 1·1·1·1·1·1·0·1 = 0	1·1·1·1·1·1·1·1 = 1 1·1·1·1·1·1·0·1 = 0
1(.5)(.25)·1·1·(.5)·1·0 = 0 1(.5)(.25)·1·1·(.5)·1·1 = .1 1(.5)(.25)·1·1·(.5)·0·1 = 0 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 1(.5)(.25)·1·1·1·0·1 = 0	1(.5)(.25)·1·1·(.5)·1·0 = 0 1(.5)(.25)·1·1·(.5)·1·1 = .1 1(.5)(.25)·1·1·(.5)·0·1 = 0 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 1(.5)(.25)·1·1·1·0·1 = 0
1. Reference TM9-1370-200. 2. Chute opens at not more than 100' below a/c. 3. Designed for emergency night landings. 4. Launched at a/c speeds up to 200 mph.	1. Reference TM9-1370-200. 2. Intended for reconnaissance use. 3. Launched at a/c speeds up to 200 mph.

TABLE B-5 (Cont)

Flare, Aircraft, Parachute M26A1 (AN-M26)/M26	Flare, Aircraft, Parachute M138	M139
Yellowish		
Yes	Yes	
No	No	
Air dropped	Air dropped	
5-92	5-92	
N/A	N/A	
195 ± 15	360	180
575,000-1,000,000	1,500	3,000
2512	1400	
52.5	62	
1(.5)(.25)·1·1(.5)·1·0 = 0	1(.5)(.25)·1·1(.5)·1·0 = 0	
1(.5)(.25)·1·1(.5)·1·1 = .1	1(.5)(.25)·1·1(.5)·1·1 = .1	
1(.5)(.25)·1·1(.5)·0·1 = 0	1(.5)(.25)·1·1·(.5)·0·1 = 0	
1(.5)(.25)·1·1·1·1·0 = 0	1(.5)(.25)·1·1·1·1·0 = 0	
1(.5)(.25)·1·1·1·1·1 = .125	1(.5)(.25)·1·1·1·1·1 = .125	
1(.5)(.25)·1·1·1·0·1 = 0	1(.5)(.25)·1·1·1·0·1 = 0	
1·1·1·1·1·1·1·1 = 1	1·1·1·1·1·1·1·1 = 1	
1·1·1·1·1·1·0·1 = 0	1·1·1·1·1·1·0·1 = 0	
1(.5)(.25)·1·1(.5)·1·0 = 0	1(.5)(.25)·1·1(.5)·1·0 = 0	
1(.5)(.25)·1·1(.5)·1·1 = .1	1(.5)(.25)·1·1(.5)·1·1 = .1	
1(.5)(.25)·1·1(.5)·0·1 = 0	1(.5)(.25)·1·1(.5)·0·1 = 0	
1(.5)(.25)·1·1·1·1·0 = 0	1(.5)(.25)·1·1·1·1·0 = 0	
1(.5)(.25)·1·1·1·1·1 = .125	1(.5)(.25)·1·1·1·1·1 = .125	
1(.5)(.25)·1·1·1·0·1 = 0	1(.5)(.25)·1·1·1·0·1 = 0	
1. Reference TM9-1370-200. 2. Intended for night illumination. 3. Illuminates region 1500 ft. in diameter. 4. With fuze can be released from altitudes 2500-25,000 ft. above functioning level. 5. Released at A/C speeds up to 350mph.	1. Reference TM9-1370-200. 2. Intended for reconnaissance and illumination for night bombardments at medium altitudes. 3. Illuminates terrain 5000 ft in diameter. 4. Released from altitudes of 7500-10,000 ft. at speeds up to 440mph.	

TABLE B-5 (Cont)

Flare, Aircraft, Parachute MK5 and Mods	MK6, Mod 6,5	MK24 Mods 1,2,2A,3	AN-MK8 Mods 1,2
		Yes	
		No	
		Air Dropped	
180	150	180	180
		N/A	
180	150	180	180
600,000-1,250,000	1,000,000	2,000,000	500,000
478	810	668	444
18	30	24	18

$1(.5)(.25)\cdot1\cdot1(.5)\cdot1\cdot0 = 0$
$1(.5)(.25)\cdot1\cdot1(.5)\cdot1\cdot1 = .1$

$1(.5)(.25)\cdot1\cdot1\cdot(.5)\cdot0\cdot1 = 0$

$1(.5)(.25)\cdot1\cdot1\cdot1\cdot1\cdot0 = 0$
$1(.5)(.25)\cdot1\cdot1\cdot1\cdot1\cdot1 = .125$

$1(.5)(.25)\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$

$1\cdot1\cdot1\cdot1\cdot1\cdot1\cdot1\cdot1 = 1$

$1\cdot1\cdot1\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$

$1(.5)(.25)\cdot1\cdot1\cdot(.5)\cdot1\cdot0 = 0$
$1(.5)(.25)\cdot1\cdot1\cdot(.5)\cdot1\cdot1 = .1$

$1(.5)(.25)\cdot1\cdot1\cdot(.5)\cdot0\cdot1 = 0$

$1(.5)(.25)\cdot1\cdot1\cdot1\cdot1\cdot0 = 0$
$1(.5)(.25)\cdot1\cdot1\cdot1\cdot1\cdot1 = .125$

$1(.5)(.25)\cdot1\cdot1\cdot1\cdot0\cdot1 = 0$

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1. Reference TM9-1370-200.
2. Intended for illuminating a large area to permit reconnoitering bombing or landing or aircraft.

TABLE B-5 (Cont)

Flare, Aircraft, Towed		Flare Set, Aircraft
M78	M79	AN/ALA-17
A	G	
Yes		Yes
No		No
Air released		Fired from ejector
0		
N/A		N/A
360 ± 30		
70,000	90,000	
7-9mi at 5000' in daytime	6-8mi at 5000' in daytime	
380		877/set
21		41/set
1(.5)(.5)·1·1(.5)·1·1	= .125	1(.5)(.25)·1·1(.5)·1·0 = 0
	= .125	1(.5)(.25)·1·1(.5)·1·1 = .1
	= .125	1(.5)(.25)·1·1(.5)·0·1 = 0
1(.5)(.5)·1·1·1·1·1	= .25	1(.5)(.25)·1·1·1·1·0 = 0
	= .25	1(.5)(.25)·1·1·1·1·1 = .125
	= .25	1(.5)(.25)·1·1·1·0·1 = 0
1·1·1·1·1·1·1·1	= 1	1·1·1·1·1·1·1·1 = 1
	= 1	1·1·1·1·1·1·0·1 = 0
1(.5)(.5)·1·1(.5)·1·1	= .125	1(.5)(.25)·1·1(.5)·1·0 = 0
	= .125	1(.5)(.25)·1·1(.5)·1·1 = .1
	= .125	1(.5)(.25)·1·1·(.5)·0·1 = 0
1(.5)(.5)·1·1·1·1·1	= .25	1(.5)(.25)·1·1·1·1·0 = 0
	= .25	1(.5)(.25)·1·1·1·1·1 = .125
	= .25	1(.5)(.25)·1·1·1·0·1 = 0
1. Reference TM9-1370-200. 2. Released at A/C speeds up to 200 mph.		1. Reference TM9-1370-200. 2. Set consists of rack and 8 cartridges, 2 flares per cartridge.

TABLE B-5 (Cont)

Flare, Guided Missile, Tracking		Flare, Aircraft, Target Marker		
M136	M137	LLU-1/B		
		R	G	F
Yes		Yes		
No		No		
Electrical		MK-24 Launcher		
		5-30		
N/A		N/A		
75	90	1740[4]	1860[4]	1620[4]
70,000				
		21[5]	14.5[5]	13.5[5]
25.1	51.5	340		
		16		
1(.5)(.25)·1·1(.5)·1·1 = .1		(.78)(.5)(.75)·1·1·(.5)·1·1 = .15		
= .1		= .15		
= .1		(.78)(.5)(.75)·1·1·(.5)·0·1 = 0		
1(.5)(.25)·1·1·1·1·1 = .125		(.78)(.5)(.75)·1·1·1·1·1 = .3		
= .125		= .3		
= .125		(.78)(.5)(.75)·1·1·1·0·1 = 0		
1·1·1·1·1·1·1·1 = 1		(.78)(.5)·1·1·1·1·1·1 = .38		
= 1		(.78)(.5)·1·1·1·1·0·1 = 0		
1(.5)(.25)·1·1(.5)·1·1 = .1		(.78)·1·(.75)·1·1·(.5)·1·1 = .3		
= .1		= .3		
= .1		(.78)·1·(.75)·1·1·(.5)·0·1 = 0		
1(.5)(.25)·1·1·1·1·1 = .125		(.78)·1·(.75)·1·1·1·1·1 = .6		
= .125		= .6		
= .125		(.78)·1·(.75)·1·1·1·0·1 = 0		
1. Reference TM9-1370-200.		1. Reference APGC Report. AD825828. 2. Canopy hang-up capability. 3. Test of 27 flares established functional reliability of .78. 4. Average values from tests. 5. Average values from tests. Open areas.		

TABLE B-5 (Cont)

Target Marker, Aircraft, Flare and Smoke MLU-46/B	Aerial Illumination Flare LWL-
Yes No	Yes No
Air dropped by hand.	E-14 dispenser
368[4]	480 ?
11.8[4] from 5000 feet 98.8 37.5	0.1
(.85)(.5)(.25)·1·1·1·1·1 = .1 = .1 = .1 = .1 = .1 = .1	
(.85)(.5)·1·1·1·1·1·1 = .43 = .43	
(.85)·1·(.25)·1·1·1·1·1 = .21 = .21 = .21 = .21 = .21 = .21	
1. Reference APGC Report. AD 826 001. 2. Functional reliability of .85 established from test of 13 units. 3. Provides day/night capability on any type of terrain and on water. 4. Average values from tests.	

TABLE B-6

FLARE, GROUND

Name of Device				Flare, Surface, Airport
Identification Number				M76
Color(s)				Deep Yellow
Air Launch				No
Ground Launch				Yes
Function	Launch Requirements			Hand or Electric squib.
	Init. Time (sec)			0
	Ht. (ft)			N/A
	Pers (sec)			300-420
	CP			600,000-850,000
	Range			25-30 mi. clear night, 20 mi. cloudy
	Vol (in³)			447
	Wt(lbs)			27.61
	Light	Terrain	Veg	
Signal	Day	Land	Canopy	1(.5)(.25)·1·1·(.5)·1·0 = 0
			No Can	1(.5)(.25)·1·1·(.5)·1·1 = .1
		Water	No Can	1(.5)(.25)·1·1·(.5)·0·1 = 0
	Night	Land	Canopy	1(.5)(.25)·1·1·1·1·0 = 0
			No Can	1(.5)(.25)·1·1·1·1·1 = .125
		Water	No Can	1(.5)(.25)·1·1·1·0·1 = 0
Illumination	Night	Land	No Can	1·1·1·1·1·1·1·1 = 1
		Water	No Can	1·1·1·1·1·1·0·1 = 0
Marker	Day	Land	Canopy	1(.5)(.25)·1·1·(.5)·1·0 = 0
			No Can	1(.5)(.25)·1·1·(.5)·1·1 = .1
		Water	No Can	1(.5)(.25)·1·1·(.5)·0·1 = 0
	Night	Land	Canopy	1(.5)(.25)·1·1·1·1·0 = 0
			No Can	1(.5)(.25)·1·1·1·1·1 = .125
		Water	No Can	1(.5)(.25)·1·1·1·0·1 = 0
REMARKS				1. Reference TM9-1370-200.

TABLE B-6 (Cont)

Flare, Surface, Trip M49A1 | M49 Yellowish white No Yes	Landing Light System LWL 09-E-67 Colored filters available. No Yes
Trip wire 0 N/A 55-70 | 55 40,000	Hand placed 0 N/A 43,200
8.26 | 47.7 0.75 | 1.50	3 mi
1·1(.25)·1·1·(.5)·1·0 = 0 1·1(.25)·1·1·(.5)·1·1 = .125 1·1(.25)·1·1(.5)·0·1 = 0 1·1(.25)·1·1·1·1·0 = 0 1·1(.25)·1·1·1·1·1 = .25 1·1(.25)·1·1·1·0·1 = 0	1(.5)·1·1·1·(.5)·1·0 = 0 1(.5)·1·1·1·(.5)·1·1 = .25 1(.5)·1·1·1·(.5)·0·1 = 0 1(.5)·1·1·1·1·1·0 = 0 1(.5)·1·1·1·1·1·1 = .5 1(.5)·1·1·1·1·0·1 = 0
1·1·1·1·1·1·1·1 = 1 1·1·1·1·1·1·0·1 = 0	1·1·1·1·1·1·1·1 = 1 1·1·1·1·1·1·0·1 = 0
1(.5)(.25)·1·1(.5)·1·0 = 0 1(.5)(.25)·1·1(.5)·1·1 = .1 1(.5)(.25)·1·1(.5)·0·1 = 0 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 1(.5)(.25)·1·1·1·0·1 = 0	1(.5)·1·1·1·(.5)·1·0 = 0 1(.5)·1·1·1·(.5)·1·1 = .25 1(.5)·1·1·1·(.5)·0·1 = 0 1(.5)·1·1·1·1·1·0 = 0 1(.5)·1·1·1·1·1·1 = .5 1(.5)·1·1·1·1·0·1 = 0
1. Reference TM9-1370-200 and FM 20-60. 2. M49 may be hand thrown.	1. Landing strobe flash incandescent lamp.

TABLE B-6 (Cont)

Battlefield Illumination System LWL 03-F-64 | LWL 12-F-67	Remote Controlled Rocket Flare LWL 04-F-68
No Yes	No Yes
Rocket Launch | Remote Electrical	Rocket Launched. Remote Electrical.
N/A 420	N/A 1380
.12 mi.	0.2
13.0	20.0
1(.5)(.25)·1·1·(.5)·1·0 = 0 1(.5)(.25)·1·1·(.5)·1·1 = .1 = .1 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 = .125	1(.5)(.25)·1·1(.5)·1·0 = 0 1(.5)(.25)·1·1(.5)·1·1 = .1 = .1 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 = .125
1·1·1·1·1·1·1·1·1 = 1 = 1	1·1·1·1·1·1·1·1 = 1 = 1
1(.5)(.25)·1·1(.5)·1·0 = 0 1(.5)(.25)·1·1(.5)·1·1 = .1 = .1 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 = .125	1(.5)(.25)·1·1(.5)·1·0 = 0 1(.5)(.25)·1·1(.5)·1·1 = .1 = .1 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 = .125
1. Launcher with 12 illuminating candles.	1. Rocket launched with 23 illuminating candles.

TABLE B-6 (Cont)

Improved Electroluminescent Airfield Lighting LWL-07-C-67	Landing Zone Directions Signal System LWL 03-C-63
Color choices available	
No	No
Yes	Yes
Hand placed	worn
N/A	N/A
1(.5)·1·1·1·(.5)·1·0 = 0 1(.5)·1·1·1·(.5)·1·1 = .25 1(.5)·1·1·1(.5)·0·1 = 0 1(.5)·1·1·1·1·1·0 = 0 1(.5)·1 1·1·1·1·1 = .5 1(.5)·1·1·1·1·0·1 = 0	1·1·(.25)·1·1·0·1·0 = 0 1·1·(.25)·1·1·0·1·1 = 0 1·1·(.25)·1·1·0·0·1 = 0 1·1·(.25)·1·1·1·1·0 = 0 1·1(.25)·1·1·1·1·1 = .25 1·1(.25)·1·1·1·0·1 = 0
1·1·1·1·1·1·1·1 = 0 1·1 1·1·1·1·0·1 = 0	1·0·1·1·1·1·1·1 = 0 1·0·1·1·1·1·0·1 = 0
1·(.5)·1·1·1(.5)1·0 = 0 1(.5)·1 1 1(.5)·1·1 = .25 1(.5)·1·1·1(.5)·0·1 = 0 1(.5)·1·1·1·1·1·0 = 0 1(.5)·1·1·1·1·1·1 = .5 1(.5)·1·1·1·1·0·1 = 0	1(.5)·(.25)·1·1·0·1·0 = 0 1(.5)(.25)·1·1·0·1·1 = 0 1(.5)(.25)·1·1·0·0·1 = 0 1(.5)(.25)·1·1·1·1·0 = 0 1(.5)(.25)·1·1·1·1·1 = .125 1(.5)(.25)·1·1·1·0·1 = 0
1. Capable of withstanding downwash.	1. Electroluminescent signal paddles and signal apron. 2. Monochromatic. Visible only to front of user.

TABLE B-6 (Cont)

Patrol Illumination LWL		Flare, Surface, Trip, Parachute M48	
No		No	
Yes		Yes	
Self-contained.		Trip wire.	
		3	
		250-400	
25		20	
		11,000	
0.1			
1.5			
1(.5)(.25)·1·1·(.5)·1·0	= 0	1·1(.25)·1·1·(.5)·1·0	= 0
1(.5)(.25)·1·1·(.5)·1·1	= .1	1·1(.25)·1·1(.5)·1·1	= .125
	= .1	1·1(.25)·1·1(.5)·0·1	= 0
1(.5)(.25)·1·1·1·1·0	= 0	1·1(.25)·1·1·1·1·0	= 0
1(.5)(.25)·1·1·1·1·1	= .125	1·1(.25)·1·1·1·1·1	= .25
	= .125	1·1(.25)·1·1·1·0·1	= 0
1·1·1·1·1·1·1·1	= 1	1·1·1·1·1·1·1·1	= 1
	= 1	1·1·1·1·1·1·0·1	= 0
1(.5)(.25)·1·1·(.5)·1·0	= 0	1(.5)(.25)·1·1·(.5)·1·0	= 0
1(.5)(.25)·1·1(.5)·1·1	= .1	1(.5)(.25)·1·1(.5)·1·1	= .1
	= .1	1(.5)(.25)·1·1(.5)·0·1	= 0
1(.5)(.25)·1·1·1·1·0	= 0	1(.5)(.25)·1·1·1·1·0	= 0
1(.5)(.25)·1·1·1·1·1	= .125	1(.5)(.25)·1·1·1·1·1	= .125
	= .125	1(.5)(.25)·1·1·1·0·1	= 0
1. 4-6 individual candles (mini - B_1) to be fired separately.		1. Reference FM 20-60. 2. Fire vertically only.	

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13 ABSTRACT

The parameters influencing the effectiveness of simple devices used to perform signal, illumination and marker functions during a combat mission have been identified.

An expression has been developed for the "utility" of a device for performing a signal, illumination or marker function in a given environment. A technique has been developed for deriving a family of devices to be used by a combat unit for performing such functions in support of a mission. A numerical index of effectiveness is used to rank alternative families of devices. The numerical index is expressed in terms of the "utility" values of the devices used to perform functions, the probabilities of requirements for functions and the essentiality of functions to the combat mission.

The technique for deriving families of devices was not exercised during this study effort. Suggestions for collecting data to use in the technique are included.

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